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Evolution of molecular clouds

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The evolution of interstellar molecular hydrogen was studied, with a special interest for the formation and evolution of molecular clouds and star formation within them, by a two-dimensional hydrodynamical simulation performed on a rectangular grid of physical sizes on the order of 100 pc. It is filled with an initial density of ~ 1 cm^{-3}, except for one cell (~ 1 pc^2) at the centre of the grid where an accretion core of $1 - 10^3$ $M_\odot$ is placed. The grid is co-moving with the gridcentre that is on a circular orbit around the Galactic centre and that also is the guiding centre of epicyclic approximation of orbits of the matter surrounding it. The initial radial velocity is zero; to account for differential rotation the initial tangential velocity (i.e. the movement around the galactic centre) is proportional to the radial distance to the grid centre. The rate is comparable to the rotation rate at the Local Standard of Rest. The influence of galactic rotation is noticed by spiral or elliptical forms, but on much longer timescales than selfgravitation and cooling processes. Density and temperature are kept constant at the boundaries and no inflow is alowed along the tangential boundaries.

Cooling is playing an important role in the formation and stability of clouds in a homogeneous medium. Cooling causes a high fragmentation rate because the accreting core is prevented from developing a hot core. For radiative cooling we use an interstellar cooling function for HI gas with an ionization fraction $X = 0.1$ (Dalgarno & McCray,1972). There is a kink in the curve due to a change of cooling process at $T \sim 8000$ K that makes an equilibrium between two phases of density and temperature possible (Field, Goldsmith & Habing,1969). Galactic background heating by cosmic-rays, X-rays and grains is calculated for solar neighbourhood conditions (for heavy element- and grain abundances, UV field eg.) (Shull & Woods,1985) and assumed to be a constant parameter throughout the simulation. The heating processes influence the exact form of the two-phase model. Under the influence of a constant, spherical potential well and with radiative cooling and background heating taken into account an apparently random distribution of fragments and filaments of denser, colder matter with hot, low density gas between them arises from a homogeneous medium. Only some of the condensations out of the centre of the potential well are stable and become comparable in size and density to the central core; their exact parameters depend strongly on heating, that maintains temperatures of ~ 20 K in the dense (10 cm^{-3}) clouds.

The research was started with a constant, spherical gravitational potential well imposed on the grid, so the accretion core always kept its original form and mass. These simulations made clear that shapes arise that are far from spherical and mass concentrations that are comparible in size to the accretion core. In order to make a realistic simulation, the potential should be adjusted to the new density distribution. A perturbing self gravitation has been used for this purpose (Icke, 1985), but didn't change the results remarkably. This time a fully self gravitating simulation was made. That means the new potential in a cell is calculated every timestep by adding the attraction of all seperate cells on it. This can be written as a convolution of mass distribution and a point potential, and hence the new potential can easily be found by multiplication in the Fourier domain. As a point potential a smoothened 1/r potential is used.

Under a fully self gravitating potential the initial core evolves via a first stage of flattening of to half its original maximum and a few times its original area. Accretion shocks start plowing through the surrounding matter, heating it to more than 10^3 K. After the shock becomes standing the matter collected is fragmented by cooling, forming over- and underdensities in the post shock ridge. This place seems to be an ideal star birthing region. Eventually a slightly elliptical dense cloud is formed surrounded by a various subcondensations of comparable densities.

The results we found so far thus are promising and in reasonable accordance with observations as well as former research.

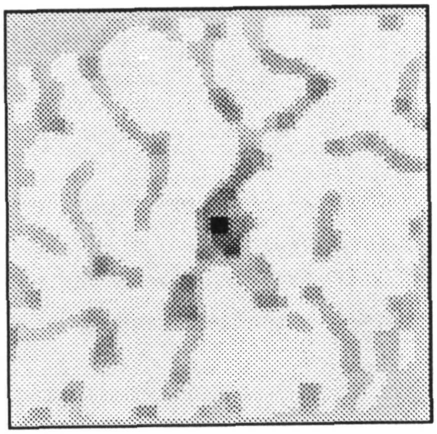

Figure 1.
Fragmentation of a homogeneous medium
by radiative cooling and background heating.

Time evolved : 0.1 Gal.yr.

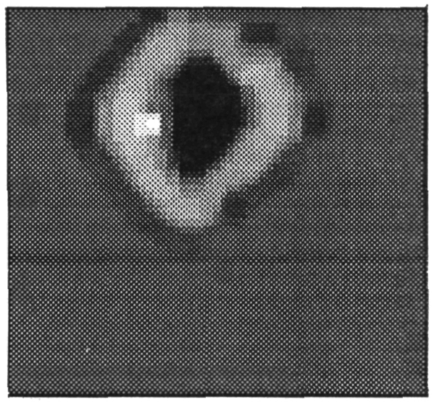

Figure 2.
Dense cores and standing shock
formed under selfgravitation and radiative
cooling from one accretion core.
Time evolved : 0.1 Gal.yr.

References :

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